Predicting Daily Land Average Temperature

Load the Data

Load the daily land-surface average anomaly data provided by Berkeley Earth collected from 1880 to 2022.

In [1]:
```
import pandas as pd

url = "https://berkeley-earth-temperature.s3.us-west-1.amazonaws.com/Global/

'''
read the data from the url link
ignore the comments starting with '%'
ignore the header in the comments and assign manually
'''
df = pd.read_csv(url, sep=r"\s+", comment="%", header=None)

# assign column headers
column_names = ["Date Number", "Year", "Month", "Day", "Day of Year", "Anoma
df.columns = column_names

# df.to_csv("../data/raw.csv", index=False)
```

In [2]:
```
df
```

Out[2]:

	Date Number	Year	Month	Day	Day of Year	Anomaly
0	1880.001	1880	1	1	1	-0.692
1	1880.004	1880	1	2	2	-0.592
2	1880.007	1880	1	3	3	-0.673
3	1880.010	1880	1	4	4	-0.615
4	1880.012	1880	1	5	5	-0.681
...	...	...	...	...	...	...
52072	2022.568	2022	7	27	208	1.639
52073	2022.571	2022	7	28	209	1.631
52074	2022.574	2022	7	29	210	1.574
52075	2022.577	2022	7	30	211	1.577
52076	2022.579	2022	7	31	212	1.629

52077 rows × 6 columns

Data Preprocessing

In [3]:
```
df.isna().sum()
```

Out[3]:
```
Date Number    0
Year           0
Month          0
Day            0
Day of Year    0
Anomaly        0
dtype: int64
```

In [4]:
```
df.dtypes
```

Out[4]:
```
Date Number    float64
Year             int64
Month            int64
Day              int64
Day of Year      int64
Anomaly        float64
dtype: object
```

In [5]:
```
# df = df.drop(columns=['Date Number'])
```

In [6]:
```
BASELINE_TEMP = 8.59  # Jan 1951–Dec 1980 land-average temperature in celsiu

df['Temperature'] = df['Anomaly'] + BASELINE_TEMP
```

In [7]:
```
month_dict = {
    1: 'January',
    2: 'February',
    3: 'March',
    4: 'April',
    5: 'May',
    6: 'June',
    7: 'July',
    8: 'August',
    9: 'September',
    10: 'October',
    11: 'November',
    12: 'December'
}

df['Month_Name'] = df['Month'].map(month_dict)
```

In [8]:
```
df
```

Out[8]:

	Date Number	Year	Month	Day	Day of Year	Anomaly	Temperature	Month_Name
0	1880.001	1880	1	1	1	-0.692	7.898	January
1	1880.004	1880	1	2	2	-0.592	7.998	January
2	1880.007	1880	1	3	3	-0.673	7.917	January
3	1880.010	1880	1	4	4	-0.615	7.975	January
4	1880.012	1880	1	5	5	-0.681	7.909	January
...	...	...	...	...	...	...	...	...
52072	2022.568	2022	7	27	208	1.639	10.229	July
52073	2022.571	2022	7	28	209	1.631	10.221	July
52074	2022.574	2022	7	29	210	1.574	10.164	July
52075	2022.577	2022	7	30	211	1.577	10.167	July
52076	2022.579	2022	7	31	212	1.629	10.219	July

52077 rows × 8 columns

Exploratory Data Analysis (EDA)

In [9]:
```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 52077 entries, 0 to 52076
Data columns (total 8 columns):
 #   Column       Non-Null Count  Dtype  
---  ------       --------------  -----  
 0   Date Number  52077 non-null  float64
 1   Year         52077 non-null  int64  
 2   Month        52077 non-null  int64  
 3   Day          52077 non-null  int64  
 4   Day of Year  52077 non-null  int64  
 5   Anomaly      52077 non-null  float64
 6   Temperature  52077 non-null  float64
 7   Month_Name   52077 non-null  object 
dtypes: float64(3), int64(4), object(1)
memory usage: 3.2+ MB
```

In [10]:
```
df.describe()
```

Out[10]:

	Date Number	Year	Month	Day	Day of Year	
count	52077.000000	52077.000000	52077.000000	52077.000000	52077.000000	5207
mean	1951.290840	1950.791693	6.512779	15.729228	182.688577	
std	41.160006	41.160470	3.447762	8.799991	105.302088	
min	1880.001000	1880.000000	1.000000	1.000000	1.000000	-
25%	1915.648000	1915.000000	4.000000	8.000000	92.000000	-
50%	1951.292000	1951.000000	7.000000	16.000000	183.000000	
75%	1986.936000	1986.000000	10.000000	23.000000	274.000000	
max	2022.579000	2022.000000	12.000000	31.000000	365.000000	

In [11]:
```
df.isna().any()
```

Out[11]:
```
Date Number    False
Year           False
Month          False
Day            False
Day of Year    False
Anomaly        False
Temperature    False
Month_Name     False
dtype: bool
```

In [12]:
```
# month order from above dict values
month_order = list(month_dict.values())
month_order
```

Out[12]:
```
['January',
 'February',
 'March',
 'April',
 'May',
 'June',
 'July',
 'August',
 'September',
 'October',
 'November',
 'December']
```

In [13]:
```
# Order the month names as categorical
df['Month_Name'] = pd.Categorical(df['Month_Name'], categories=month_order,
df['Month_Name']
```

Out[13]:
```
0        January
1        January
2        January
3        January
4        January
         ...
52072      July
52073      July
52074      July
52075      July
52076      July
Name: Month_Name, Length: 52077, dtype: category
Categories (12, object): ['January' < 'February' < 'March' < 'April' ... 'S
eptember' < 'October' < 'November' < 'December']
```

In [14]:
```
# Split into test and train dataframes based on cutoff
# beyond which we would like to score our model and use on unseen examples c
cutoff = 2018
test_df = df[df['Year']>=cutoff]
test_df
```

Out[14]:

	Date Number	Year	Month	Day	Day of Year	Anomaly	Temperature	Month_Name
50404	2018.001	2018	1	1	1	1.194	9.784	January
50405	2018.004	2018	1	2	2	1.314	9.904	January
50406	2018.007	2018	1	3	3	1.358	9.948	January
50407	2018.010	2018	1	4	4	1.390	9.980	January
50408	2018.012	2018	1	5	5	1.517	10.107	January
...	...	...	...	...	...	...	...	...
52072	2022.568	2022	7	27	208	1.639	10.229	July
52073	2022.571	2022	7	28	209	1.631	10.221	July
52074	2022.574	2022	7	29	210	1.574	10.164	July
52075	2022.577	2022	7	30	211	1.577	10.167	July
52076	2022.579	2022	7	31	212	1.629	10.219	July

1673 rows × 8 columns

In [15]:
```
train_df = df[df['Year']<cutoff]
train_df
```

Out[15]:

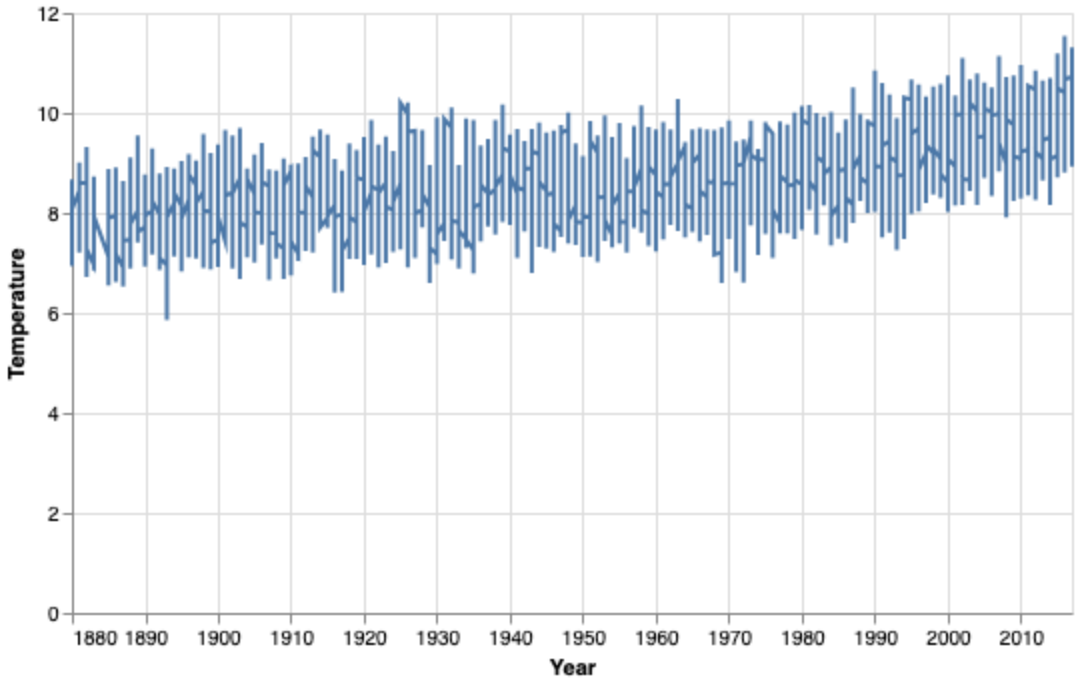
	Date Number	Year	Month	Day	Day of Year	Anomaly	Temperature	Month_Name
0	1880.001	1880	1	1	1	-0.692	7.898	January
1	1880.004	1880	1	2	2	-0.592	7.998	January
2	1880.007	1880	1	3	3	-0.673	7.917	January
3	1880.010	1880	1	4	4	-0.615	7.975	January
4	1880.012	1880	1	5	5	-0.681	7.909	January
...	...	...	...	...	...	...	...	...
50399	2017.988	2017	12	27	361	1.046	9.636	December
50400	2017.990	2017	12	28	362	1.445	10.035	December
50401	2017.993	2017	12	29	363	1.594	10.184	December
50402	2017.996	2017	12	30	364	1.506	10.096	December
50403	2017.999	2017	12	31	365	1.302	9.892	December

50404 rows × 8 columns

In [16]:
```
import altair as alt

# Simplify Working with Large Datasets
alt.data_transformers.enable('vegafusion')

# Ignore all warnings from the altair package for pdf rendering, warnings va
# resource for implementation:
# https://stackoverflow.com/questions/3920502/how-to-suppress-a-third-party-
import warnings
warnings.filterwarnings('ignore', module='altair')

# Configure Plot Sizes (D.R.Y)
small_plot_size = {'width': 500, 'height': 300}
facet_plot_size = {'width': 250, 'height': 200}
```

In [17]:
```
alt.Chart(train_df).mark_line().encode(
    x = 'Year:T',
    y = 'Temperature:Q'
).properties(**small_plot_size)

# Suffering from Overplotting, perhaps we should take the mean of the temper
```

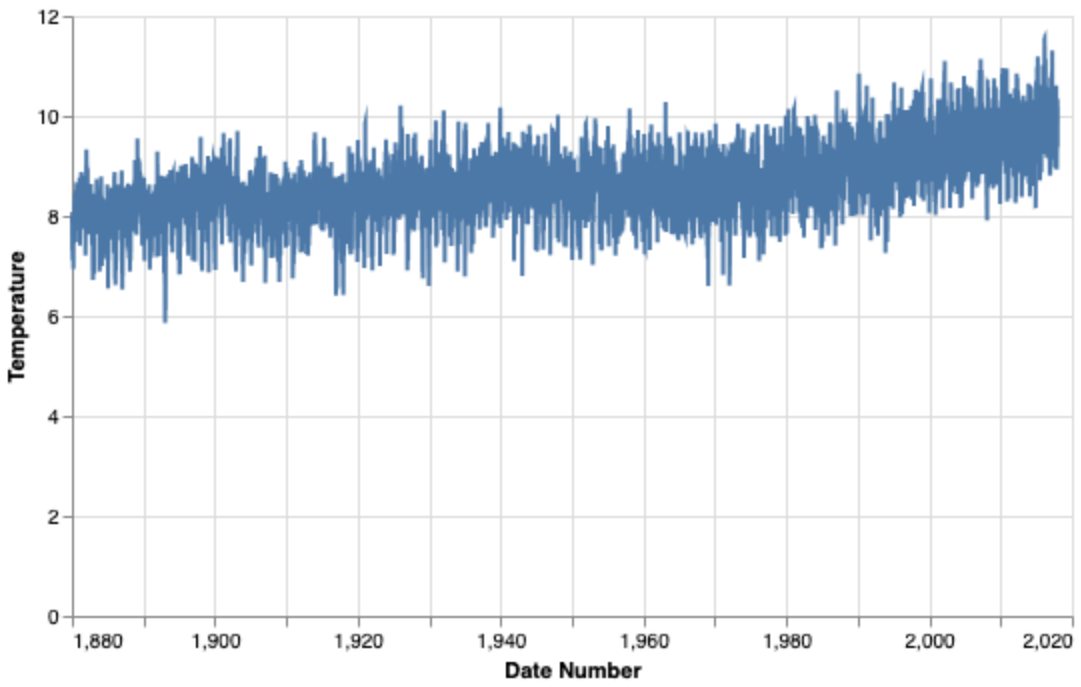
Out[17]:



In [18]:

```
temp_plot = alt.Chart(train_df).mark_line().encode(
    x = 'Date Number:Q',
    y = 'Temperature:Q'
).properties(**small_plot_size)

temp_plot
```

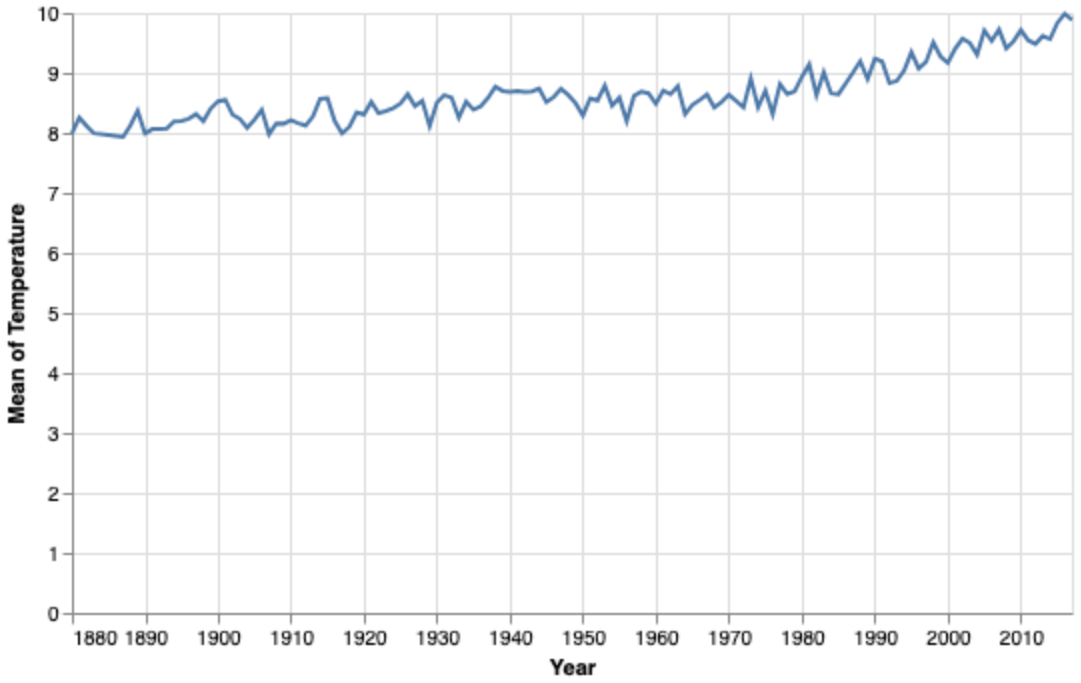
Out[18]:



In [19]:

```
temp_plot = alt.Chart(train_df).mark_line().encode(
    x = 'Year:T',
    y = 'mean(Temperature)'
).properties(**small_plot_size)

temp_plot
```

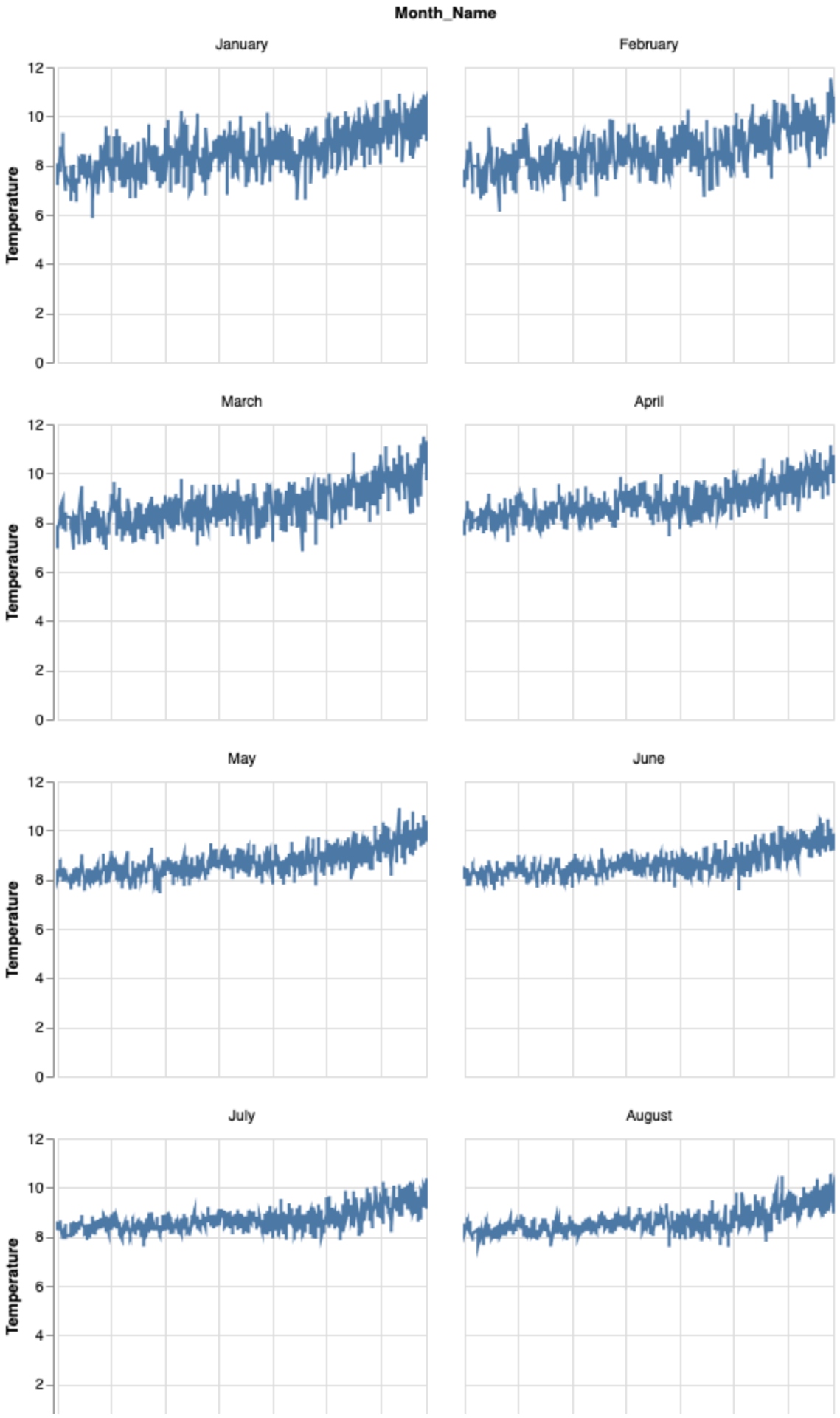
Out[19]:

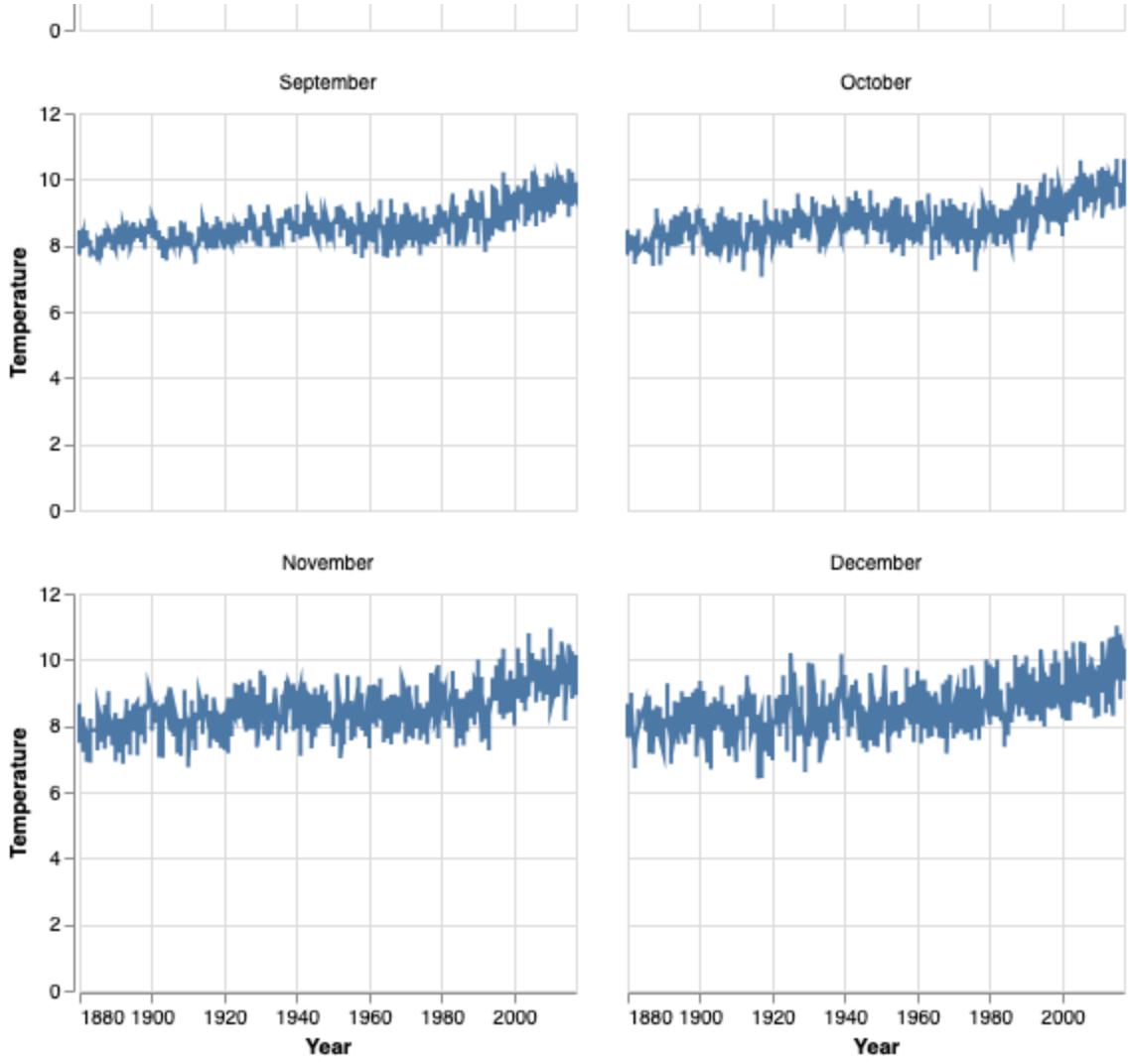


In [20]:

```
temp_plot = alt.Chart(train_df).mark_line().encode(
    x = 'Year:T',
    y = 'Temperature:Q'
).properties(**facet_plot_size).facet('Month_Name', columns=2)

temp_plot

# Suffering from Overplotting, perhaps we should take the mean of the temper
```

Out[20]:

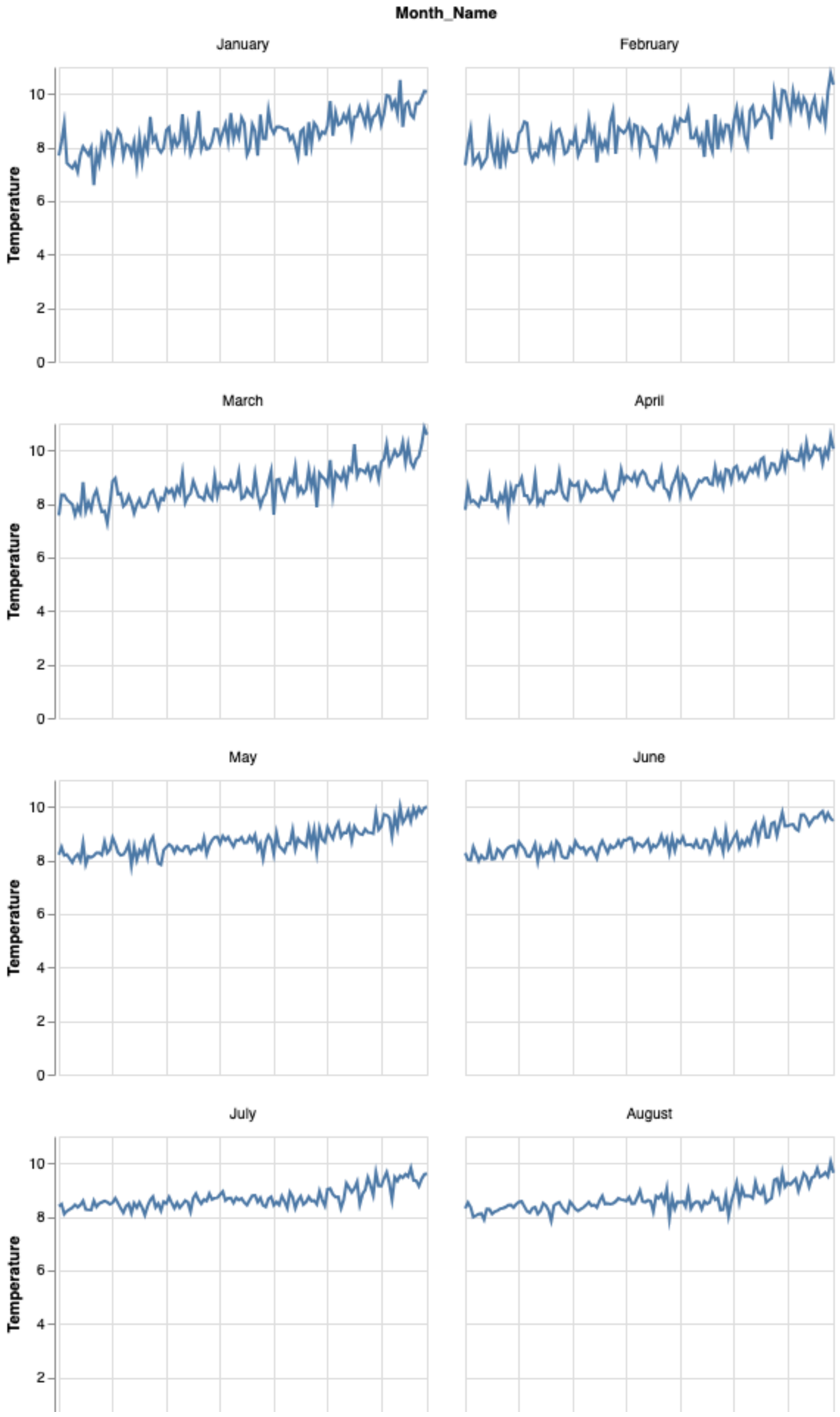

Month_Name
January
February
March
April
May
June
July
August
Temperature
0
2
4
6
8
10
12

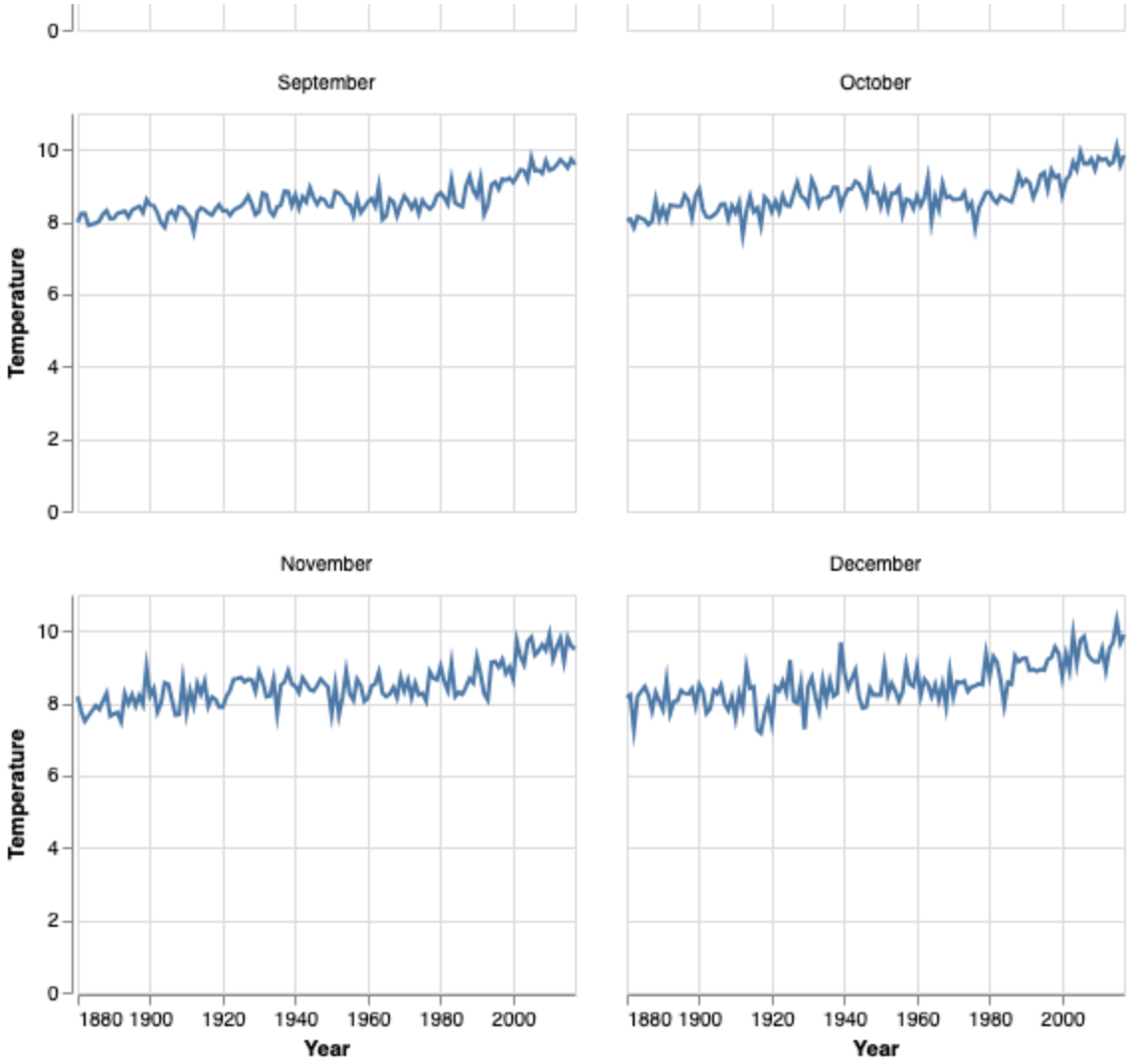


In [21]:
```
mean_per_month = train_df.groupby(['Year','Month_Name'])['Temperature'].mean

temp_plot = alt.Chart(mean_per_month).mark_line().encode(
    x = 'Year:T',
    y = 'Temperature'
).properties(**facet_plot_size).facet('Month_Name', columns=2)

temp_plot
```

```
/var/folders/b0/mpnsyl9j37s5ywbwwy416jc00000gn/T/ipykernel_78924/3969785308.
py:1: FutureWarning: The default of observed=False is deprecated and will be
changed to True in a future version of pandas. Pass observed=False to retain
current behavior or observed=True to adopt the future default and silence th
is warning.
  mean_per_month = train_df.groupby(['Year','Month_Name'])['Temperature'].me
an().reset_index()
```

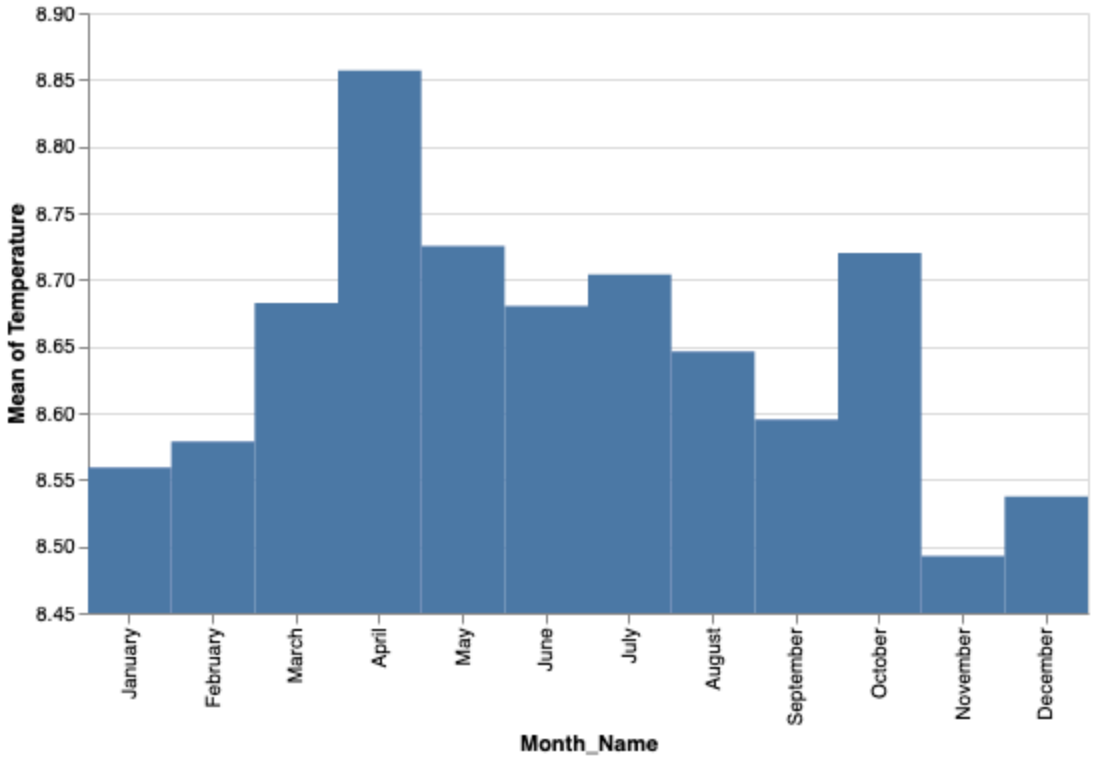
Out[21]:


Month_Name
January
February
March
April
May
June
July
August
Temperature
0
2
4
6
8
10



In [22]:
```
temp_plot = alt.Chart(train_df).mark_rect().encode(
    x = 'Month_Name',
    y = alt.Y('mean(Temperature)').scale(zero=False)
).properties(**small_plot_size)

temp_plot
```

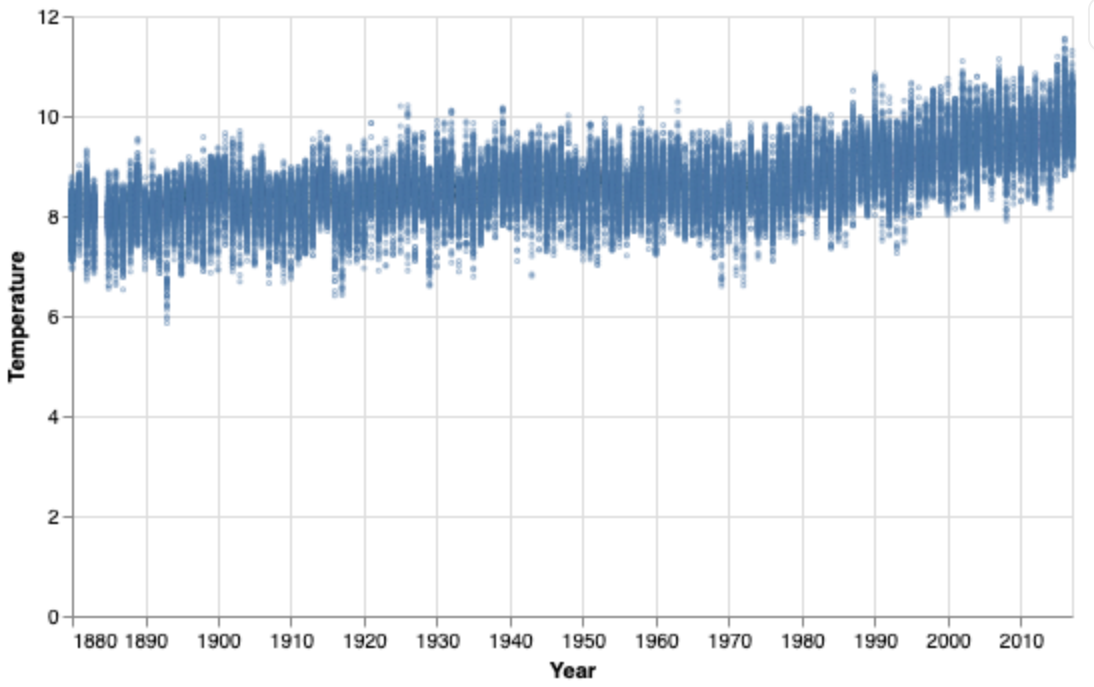
Out[22]:



In [23]:

```
temp_points = alt.Chart(train_df).mark_point(opacity=0.5, size=1).encode(
    alt.X('Year:T'),
    alt.Y('Temperature:Q')
).properties(**small_plot_size)

temp_points
```

Out[23]:

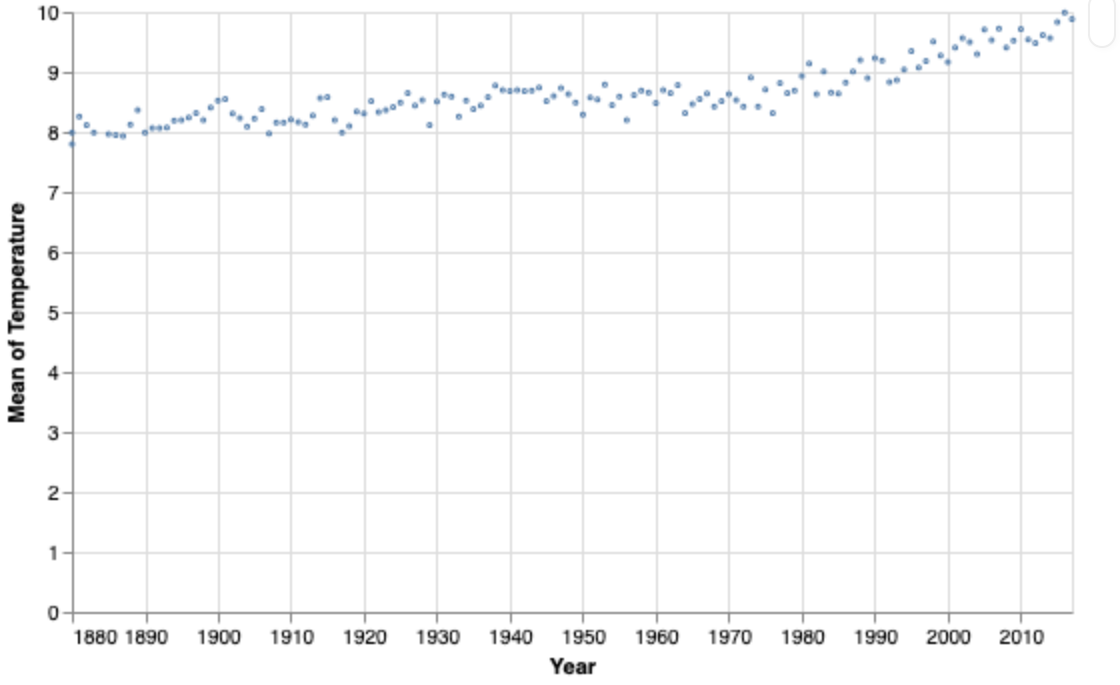


In [24]:

```
temp_points_mean = alt.Chart(train_df).mark_point(opacity=1, size=1).encode(
    alt.X('Year:T'),
    alt.Y('mean(Temperature)')
).properties(**small_plot_size)
```

```
temp_points_mean
```

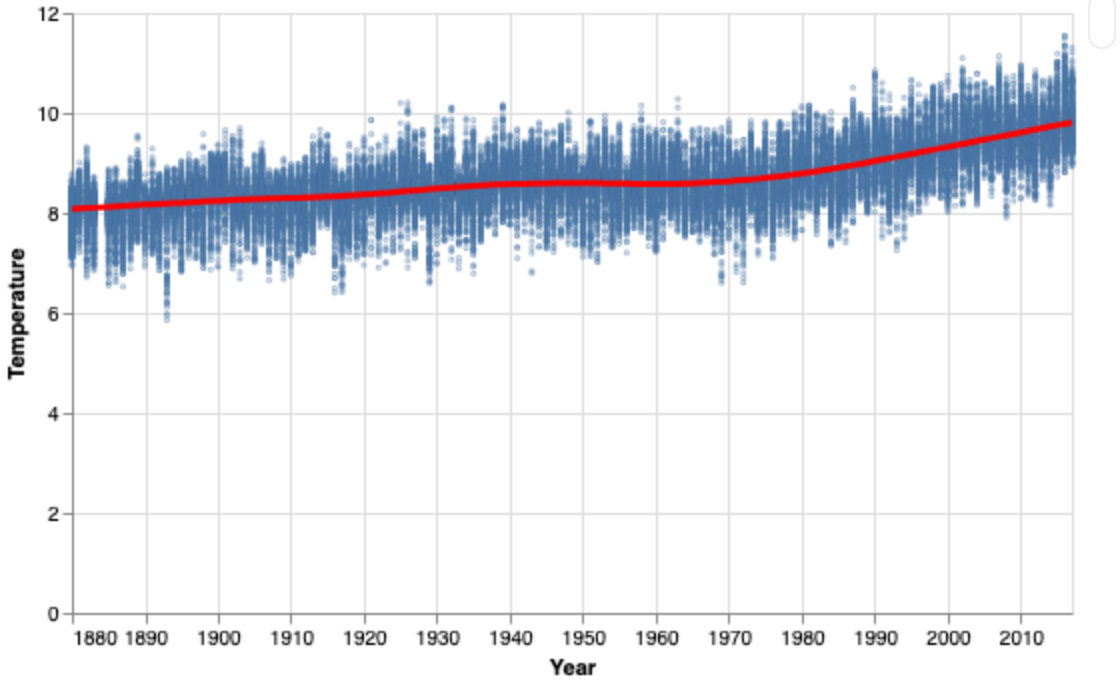
Out[24]:



In [25]:

```
temp_points +  temp_points.mark_line(size=3, color='red').transform_loess(
    'Year',
    'Temperature'
).properties(**small_plot_size)
```

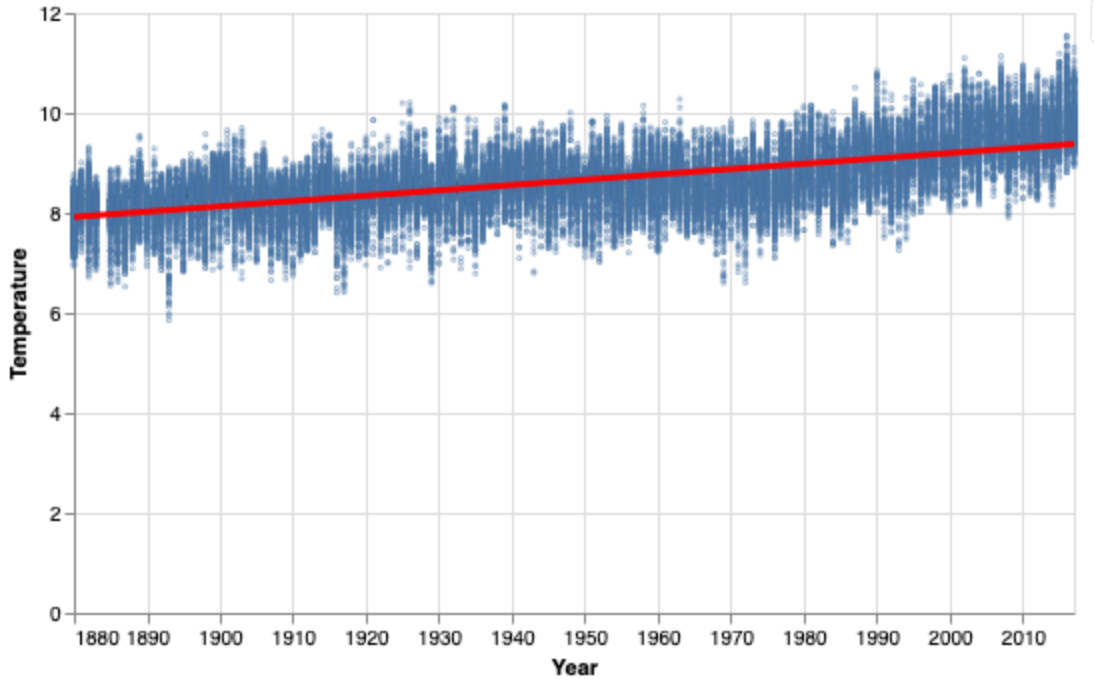
Out[25]:



In [26]:

```
temp_points +  temp_points.mark_line(size=3, color='red').transform_regressi
    'Year',
    'Temperature'
).properties(**small_plot_size)
```

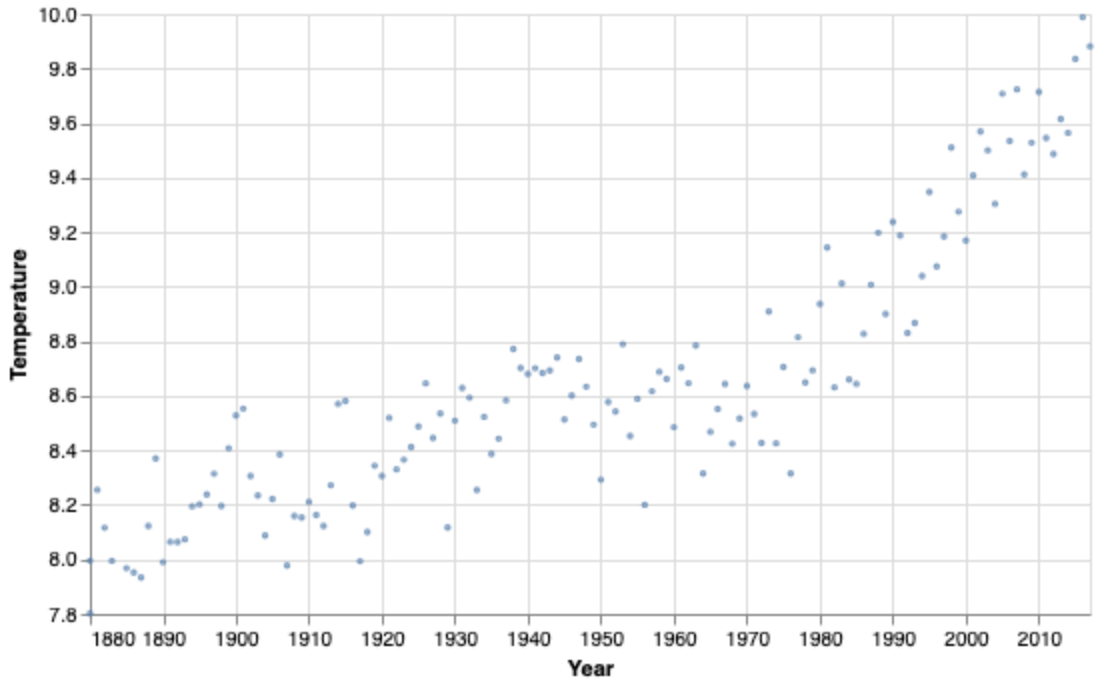
Out[26]:



In [27]:

```
mean_per_year = train_df.groupby(['Year'])['Temperature'].mean().reset_index

temp_points_avg = alt.Chart(mean_per_year).mark_point(size=2).encode(
    alt.X('Year:T'),
    alt.Y('Temperature:Q').scale(zero=False)
).properties(**small_plot_size)
temp_points_avg
```

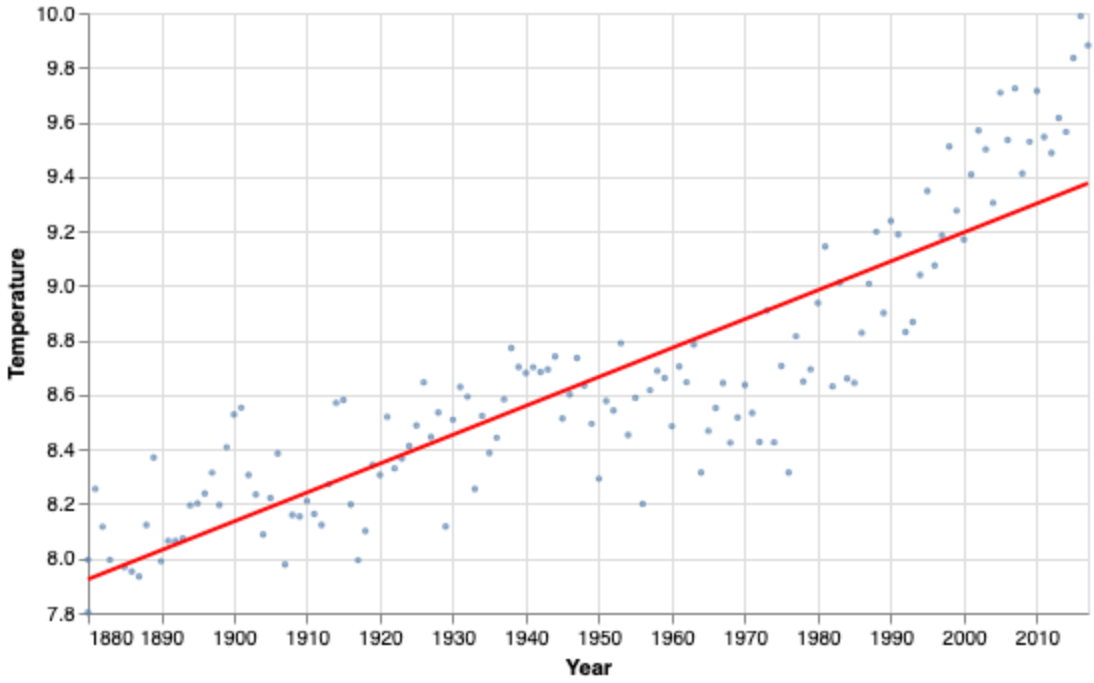
Out[27]:



In [28]:

```
reg = temp_points_avg+temp_points_avg.mark_line(size=2, color='red').transfo
    'Year',
    'Temperature'
)
reg
```

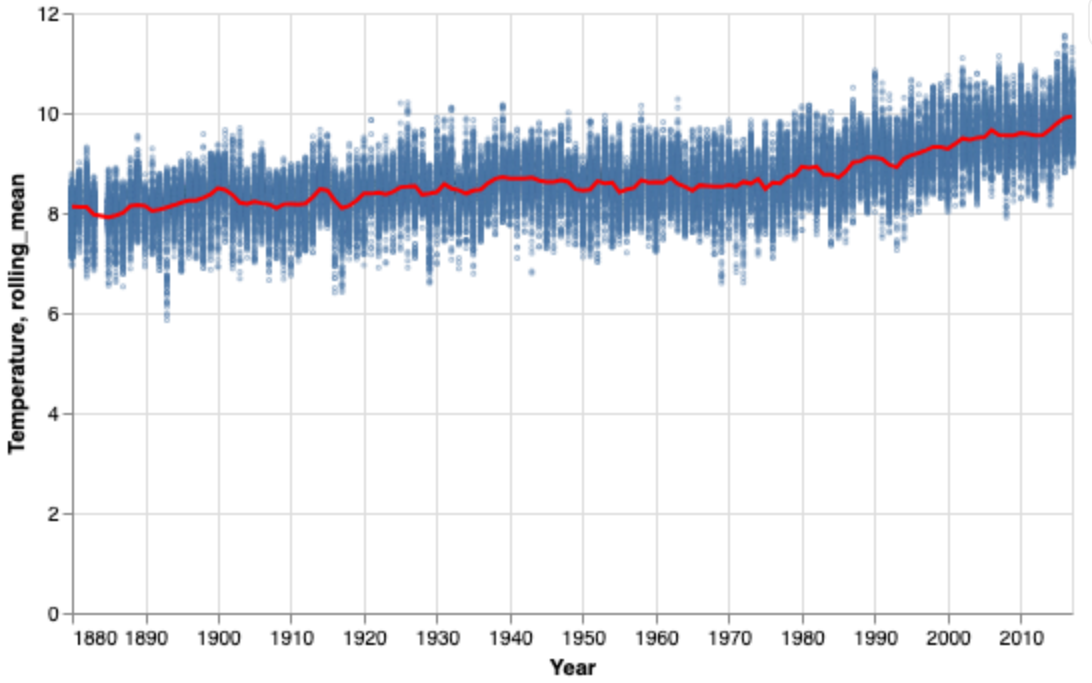
Out[28]:



In [29]:

```
# 30-day rolling average example adapted from source documentation  below:
# Adapated from 5331 Lecture 5 Notes
# https://altair-viz.github.io/gallery/scatter_with_rolling_mean.html

mean_per_year = train_df.groupby(['Year'])['Temperature'].mean().reset_index

roll_line = alt.Chart(mean_per_year).mark_line(
    color='red',
    size=2
).transform_window(
    rolling_mean='mean(Temperature)',
    frame=[-1, 1]
).encode(
    x='Year:T',
    y='rolling_mean:Q'
).properties(**small_plot_size)

# Three-year moving/rolling average (day-based moving average not easy to pl
# And day of year and day reset every new year or month
# Daily averages may be to noisy anyway we can see the rolling average smoot
temp_points+roll_line
```

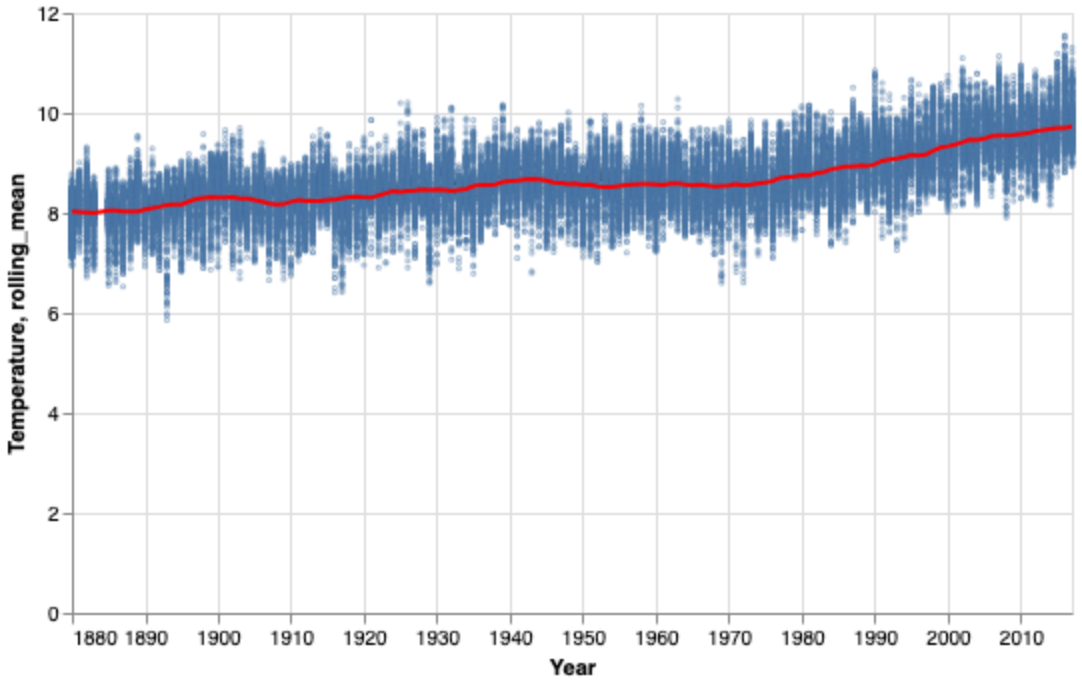
Out[29]:



In [30]:

```
mean_per_year = train_df.groupby(['Year'])['Temperature'].mean().reset_index

roll_line = alt.Chart(mean_per_year).mark_line(
    color='red',
    size=2
).transform_window(
    rolling_mean='mean(Temperature)',
    frame=[-5, 4]
).encode(
    x='Year:T',
    y='rolling_mean:Q'
).properties(**small_plot_size)

# Ten-year moving/rolling average (day-based moving average not easy to plot
# And day of year and day reset every new year or month
temp_points+roll_line
```

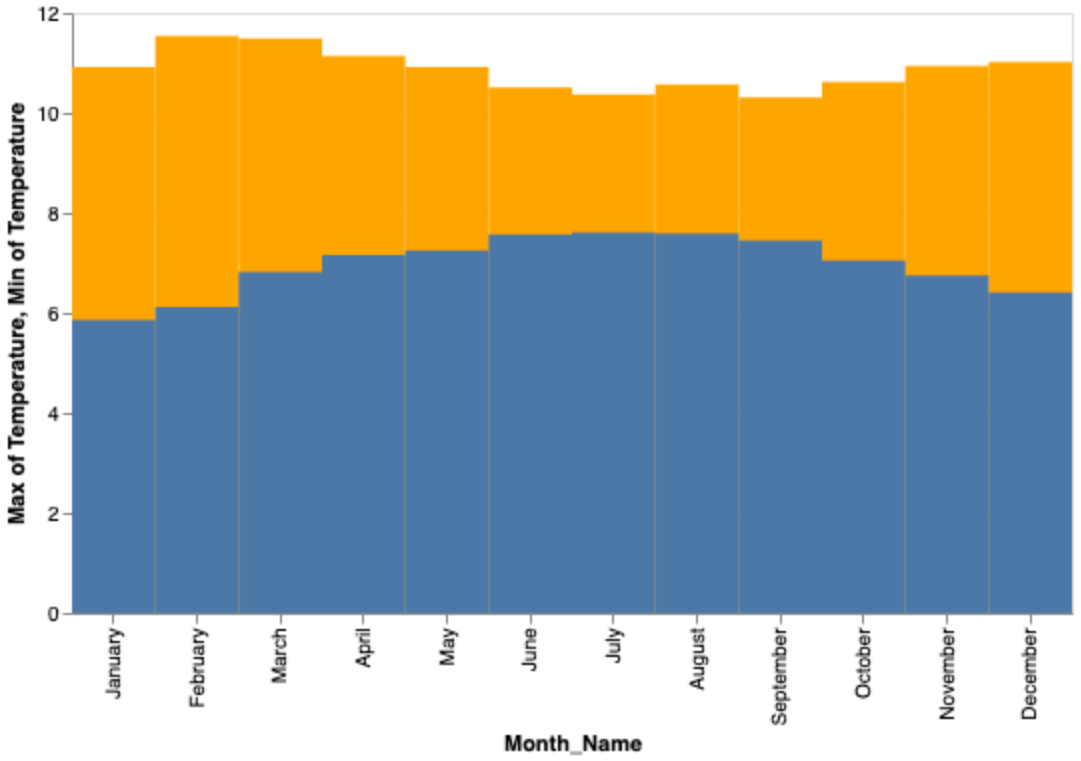
Out[30]:



In [31]:

```
temp_max = alt.Chart(train_df).mark_rect(color='orange', opacity=1).encode(
    x = 'Month_Name',
    y = 'max(Temperature)'
).properties(**small_plot_size)

temp_min = alt.Chart(train_df).mark_rect().encode(
    x = 'Month_Name',
    y = 'min(Temperature)'
)

temp_max+temp_min
```

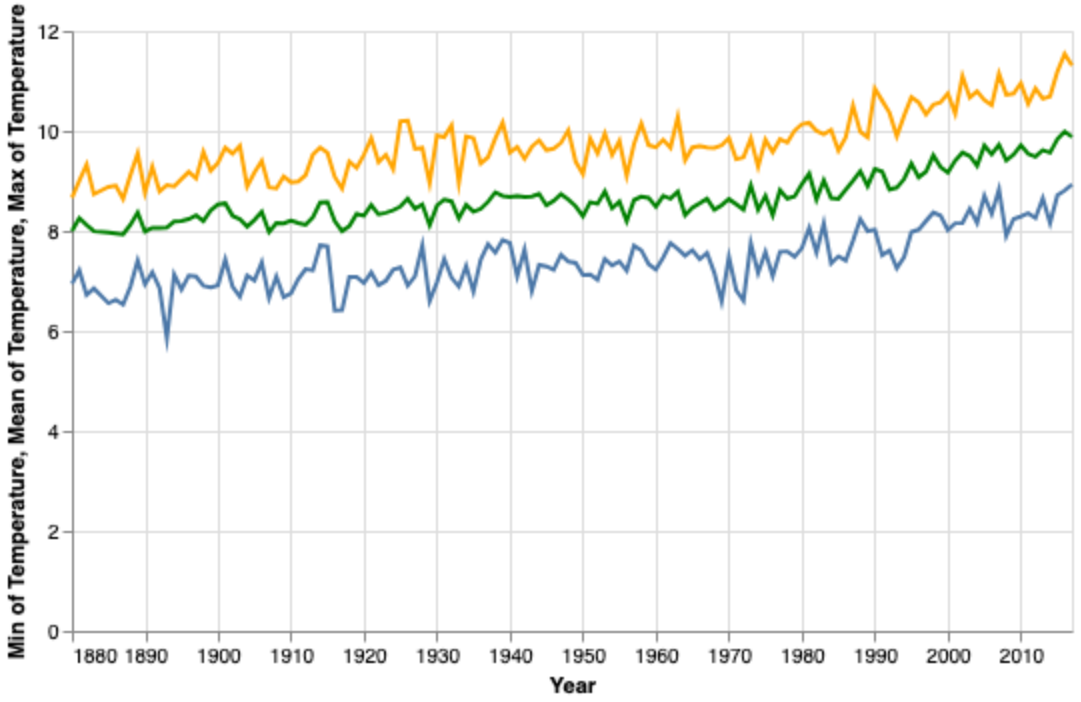
Out[31]:



In [32]:

```
temp_max = alt.Chart(train_df).mark_line(color='orange').encode(
    x = 'Year:T',
    y = 'max(Temperature)'
).properties(**small_plot_size)

temp_min = alt.Chart(train_df).mark_line().encode(
    x = 'Year:T',
    y = 'min(Temperature)'
)

temp_mean = alt.Chart(train_df).mark_line(color='green').encode(
    x = 'Year:T',
    y = 'mean(Temperature)'
)


all = temp_min+temp_mean+temp_max
all
```

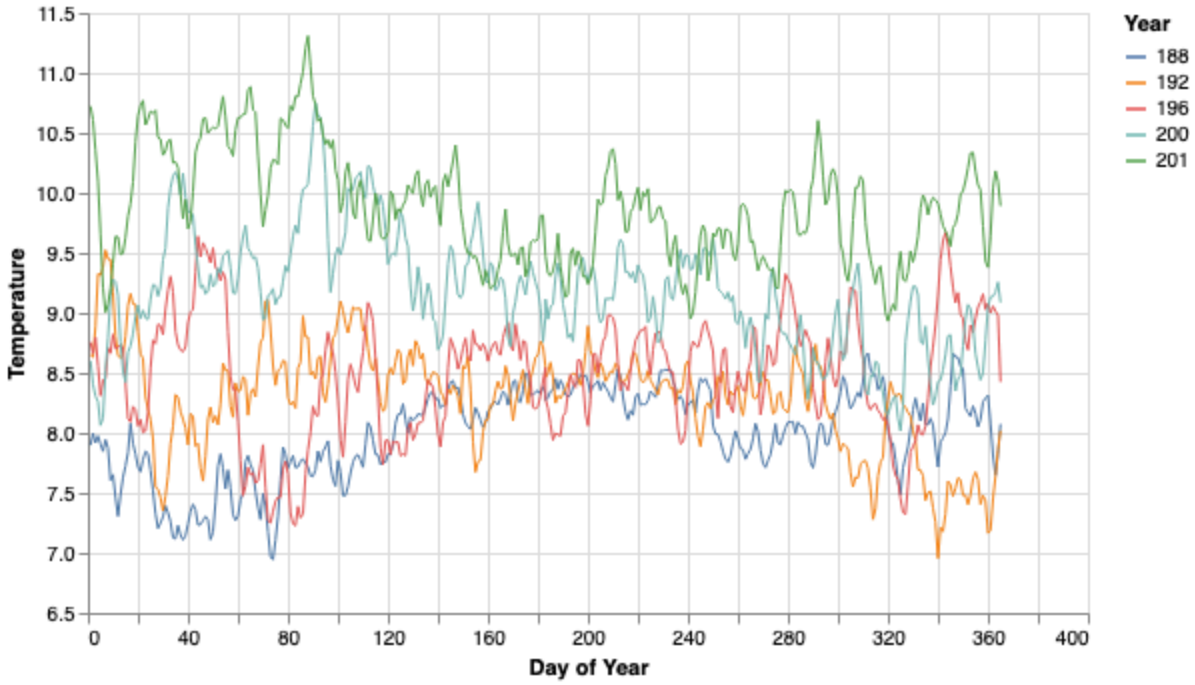
Out[32]:



In [33]:

```
years_selection = [1880, 1920, 1960, 2000, cutoff-1]

alt.Chart(train_df[train_df['Year'].isin(years_selection)]).mark_line(size=1
    x = 'Day of Year',
    y = alt.Y('Temperature').scale(zero=False),
    color = 'Year:N'
).properties(**small_plot_size)
```

Out[33]:

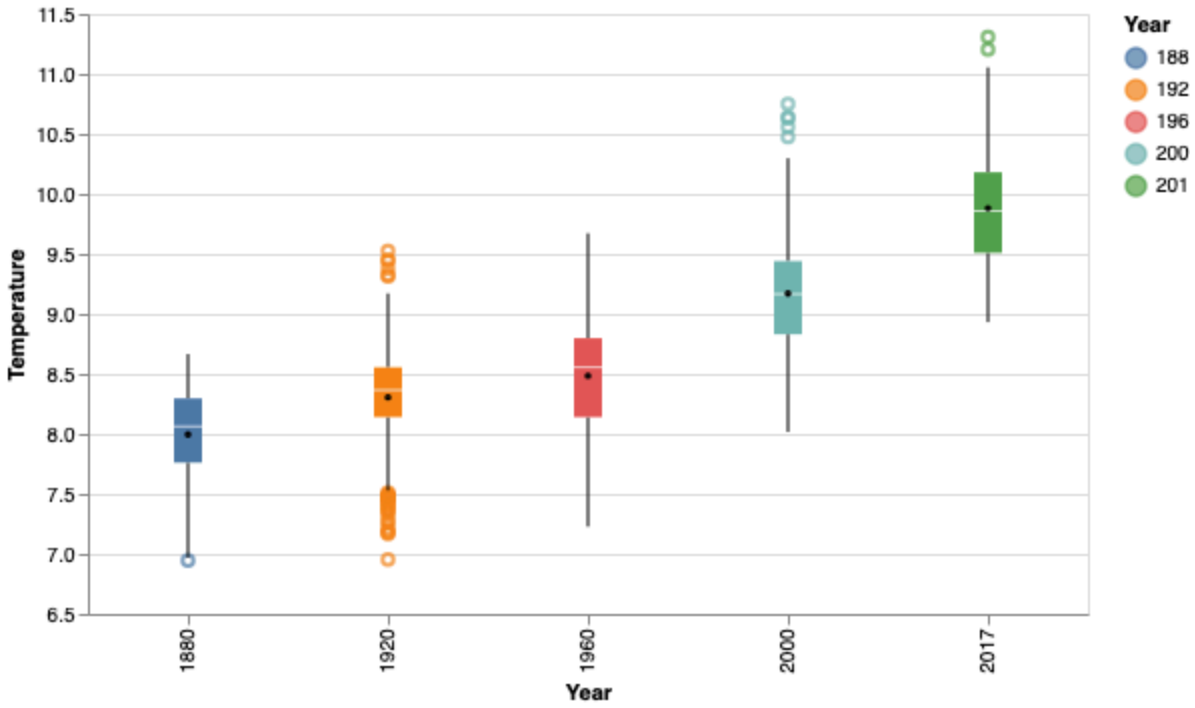


In [34]:

```
years_selection = [1880, 1920, 1960, 2000, cutoff-1]

box = alt.Chart(train_df[train_df['Year'].isin(years_selection)]).mark_boxpl
    x = 'Year:N',
```

```
    y = alt.Y('Temperature').scale(zero=False),
    color = 'Year:N'
)
box_point = alt.Chart(train_df[train_df['Year'].isin(years_selection)]).mark
    x = 'Year:N',
    y = alt.Y('mean(Temperature)').scale(zero=False),
    color = alt.value('black')
)

comb = box+box_point
comb.properties(**small_plot_size)
```

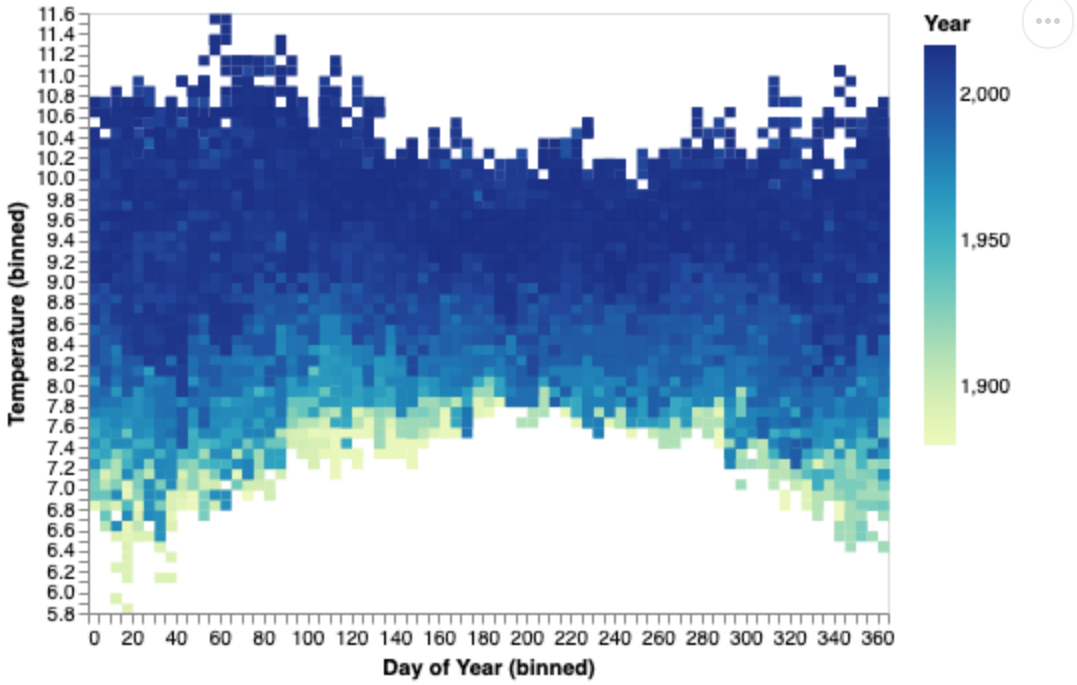
Out[34]:



In [35]:

```
alt.Chart(train_df).mark_rect().encode(
    alt.X('Day of Year').bin(maxbins=100),
    alt.Y('Temperature').bin(maxbins=100),
    alt.Color('Year')
).properties(height = 300, width = 400)
```

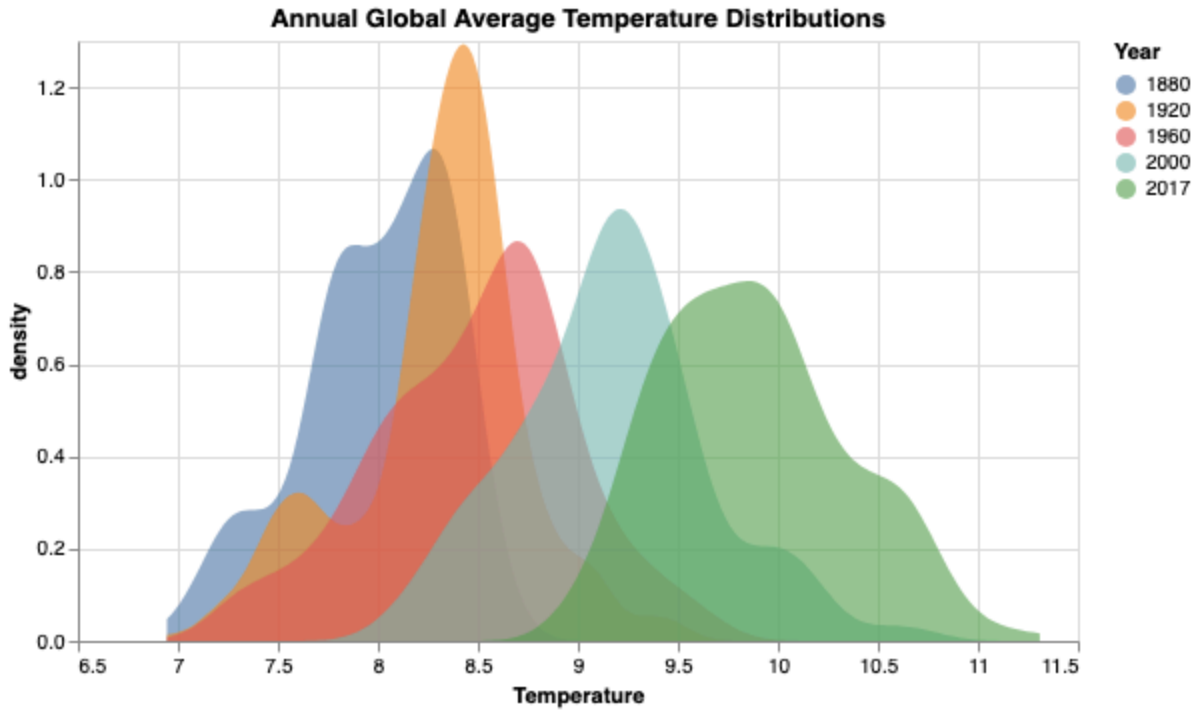
Out[35]:



In [36]:

```
temp_density  = alt.Chart(train_df[train_df['Year'].isin(years_selection)]).
    'Temperature',
    groupby=['Year'],
    as_=['Temperature', 'density']
).mark_area(opacity=0.6).encode(
    x=alt.X('Temperature',axis=alt.Axis(format='~s')),
    y=alt.Y('density:Q').stack(False),
    color = alt.Color('Year:N',
    legend = alt.Legend(orient='right',
                        title='Year',
                        direction='vertical'))
).properties(**small_plot_size, title = 'Annual Global Average Temperature D
temp_density
```

Out[36]:


Annual Global Average Temperature Distributions
Year
1880
1920
1960
2000
2017
density
0.0
0.2
0.4
0.6
0.8
1.0
1.2
6.5
7
7.5
8
8.5
9
9.5
10
10.5
11
11.5
Temperature

In [ ]: